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Steiner et al.

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(54) RADIO FREQUENCY IDENTIFICATION IN SELF-CHECKOUT

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(51) **Int. Cl.**

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A47F 9/04 (2006.01)
B65G 15/02 (2006.01)
G06K 7/10 (2006.01)

(52) **U.S. Cl.**

CPC ***G07G 1/009*** (2013.01); ***A47F 9/048*** (2013.01); ***B65G 15/02*** (2013.01); ***G06K 7/10445*** (2013.01); *A47F 2009/041* (2013.01)

(58) **Field of Classification Search**

CPC ... G07G 1/009; A47F 9/048; A47F 2009/041; B65G 15/02; G06K 7/10445

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,218,231 B2 * 5/2007 Higham G06Q 10/087 340/572.1
7,395,945 B2 * 7/2008 Godlewski A47B 49/004 221/120
2007/0030150 A1 * 2/2007 Mullins G06K 7/10336 340/572.1
2010/0194538 A1 * 8/2010 dos Reis Medeiros G06K 7/10316 340/10.1
2017/0161707 A1 * 6/2017 Chin G06K 7/10009
2017/0224438 A1 * 8/2017 Johnson A61B 90/98
2019/0263312 A1 * 8/2019 Cencer B60P 3/079

* cited by examiner

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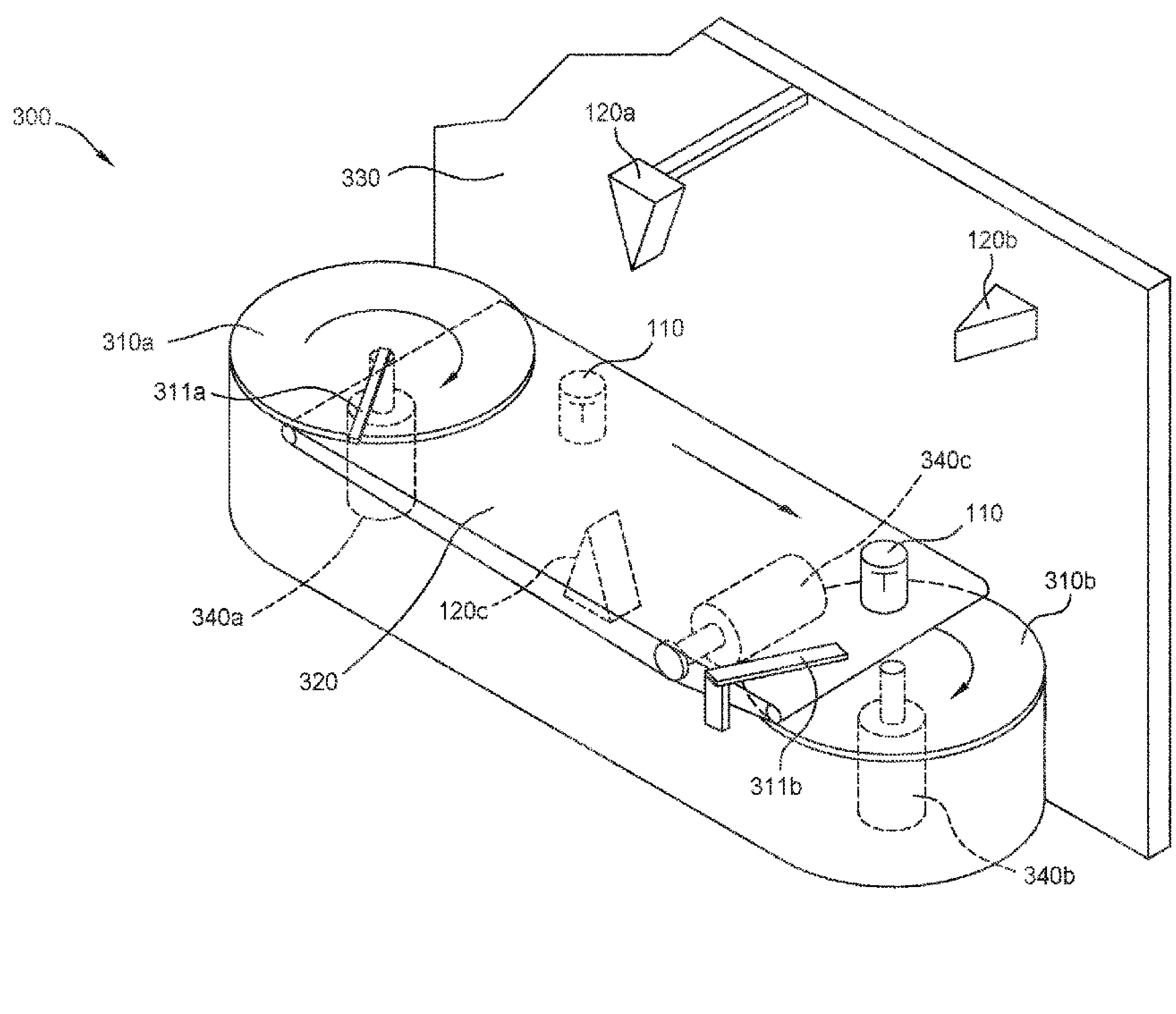
(57) **ABSTRACT**

The present disclosure provides for radio frequency identification in self-checkout via a first product pathway; a single Radio Frequency Identifier (RFID) antenna, having a first scanning zone aligned with the first product pathway; wherein the first product pathway is configured to: position a first set of objects within the first scanning zone at a first position relative to the single RFID antenna at a first time; and position the first set of object within the first scanning zone at a second position relative to the single RFID, different than the first position, at a second time; and wherein the single RFID antenna is configured to: receive, at the first time, a first set of identifier signals associated with at least some of the first set of objects; and receive, at the second time, a second set of identifier signals associated with at least some of the first set of objects.

20 Claims, 13 Drawing Sheets



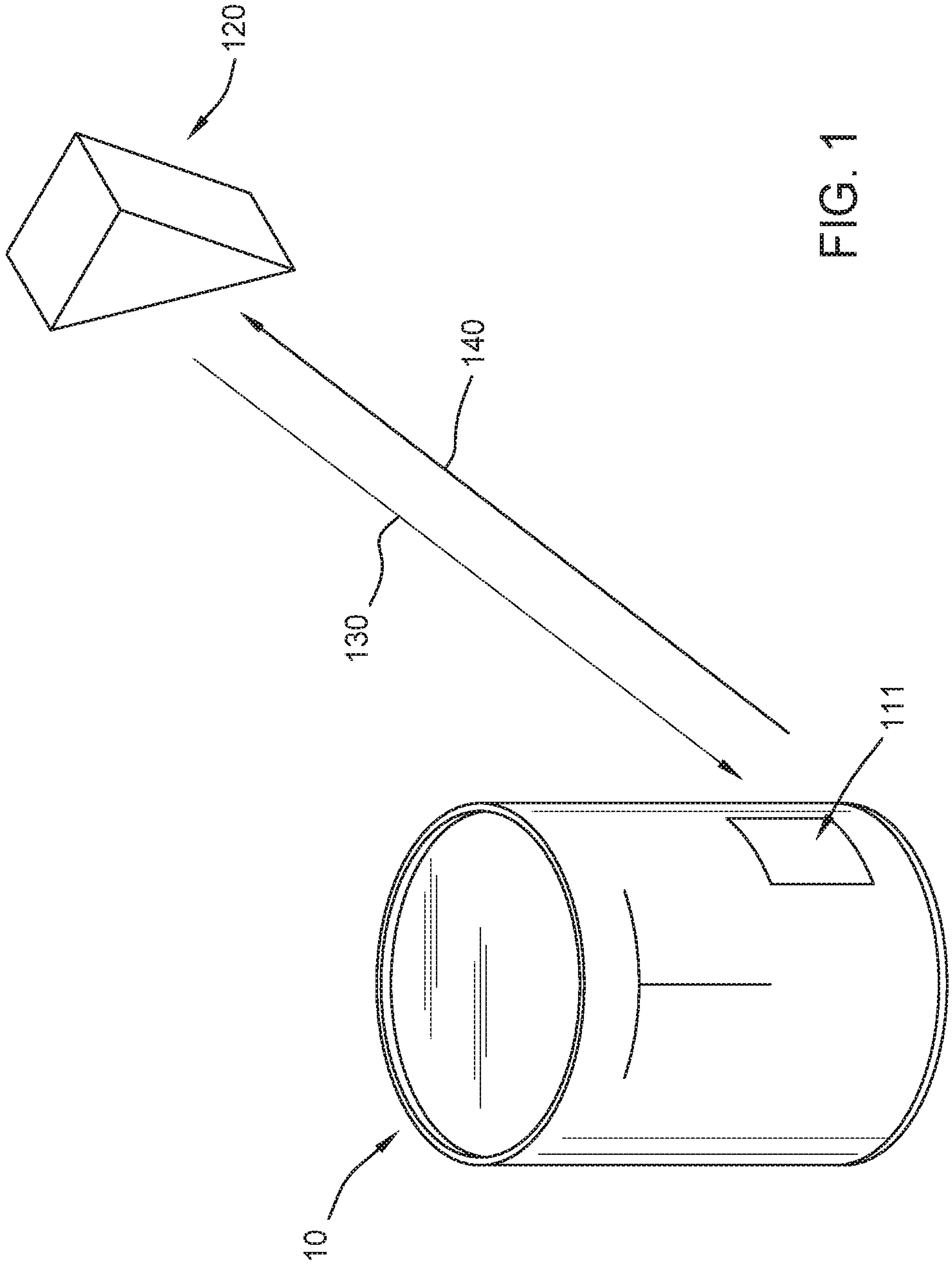


FIG. 1

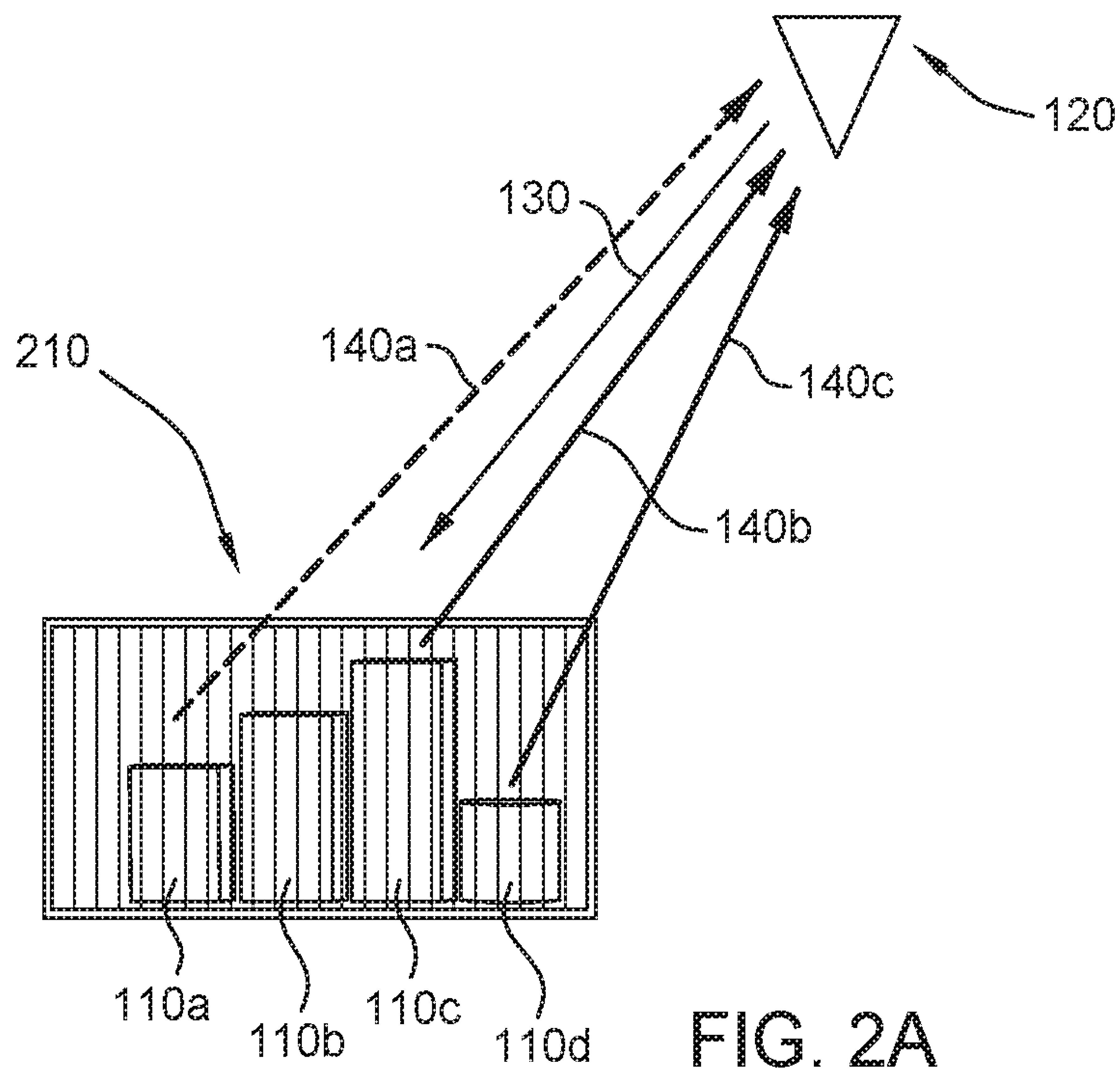

120
130
210
140a
140c
140b
110a
110b
110c
110d

FIG. 2A

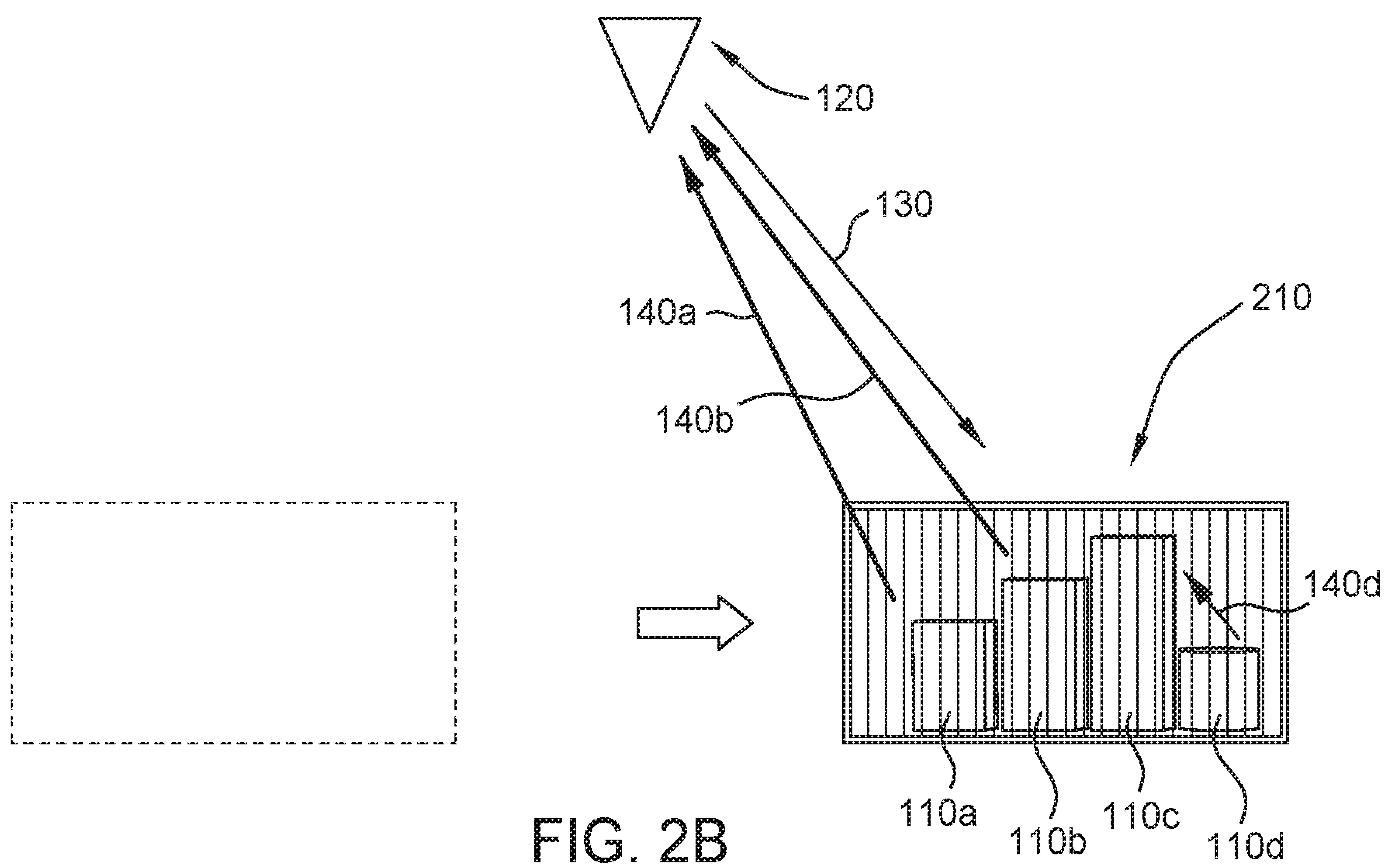

120
130
140a
210
140b
140d
110a
110b
110c
110d

FIG. 2B

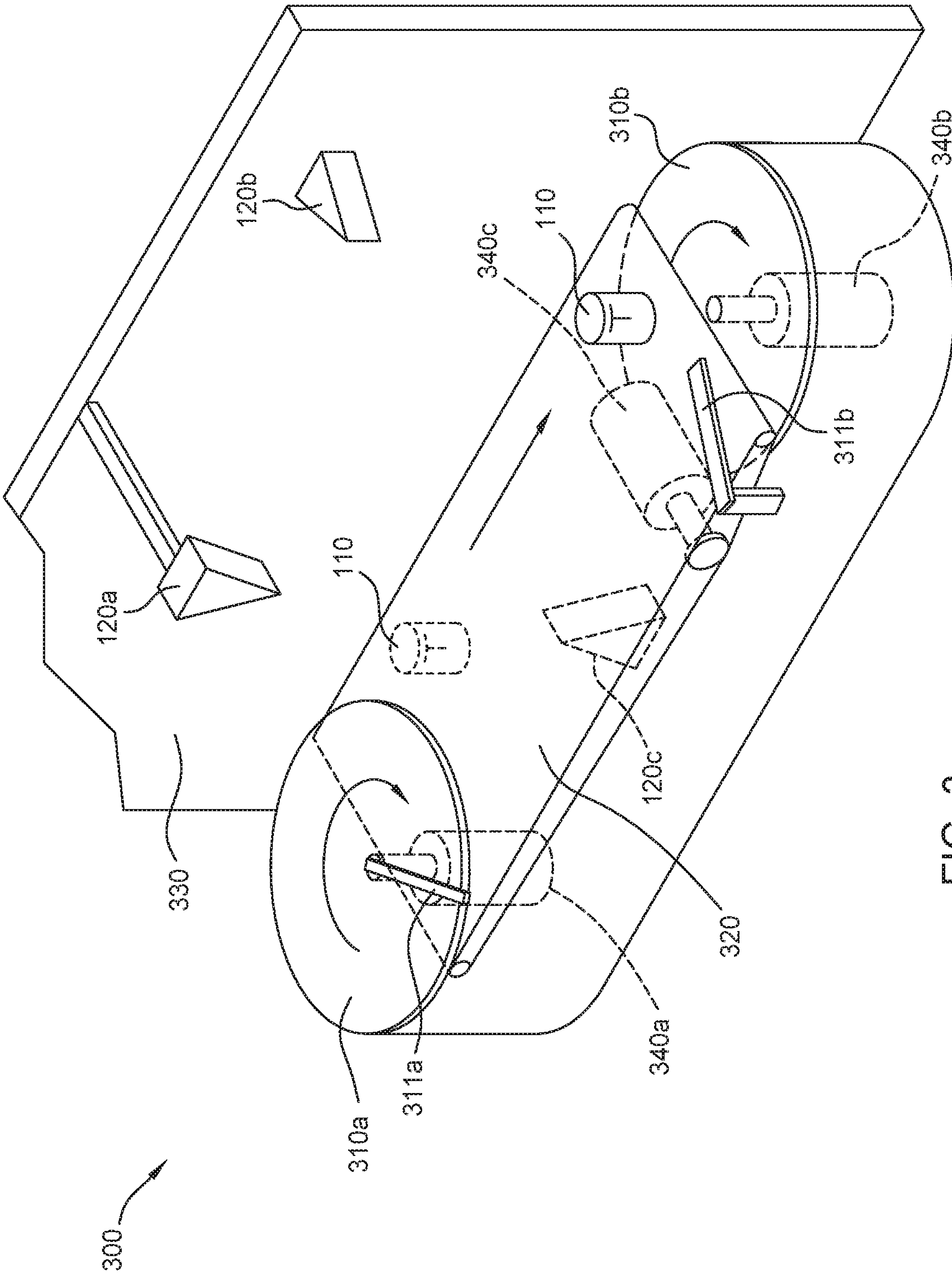

300
310a
311a
340a
320
120c
330
120a
110
110
340c
120b
310b
340b
311b

FIG. 3

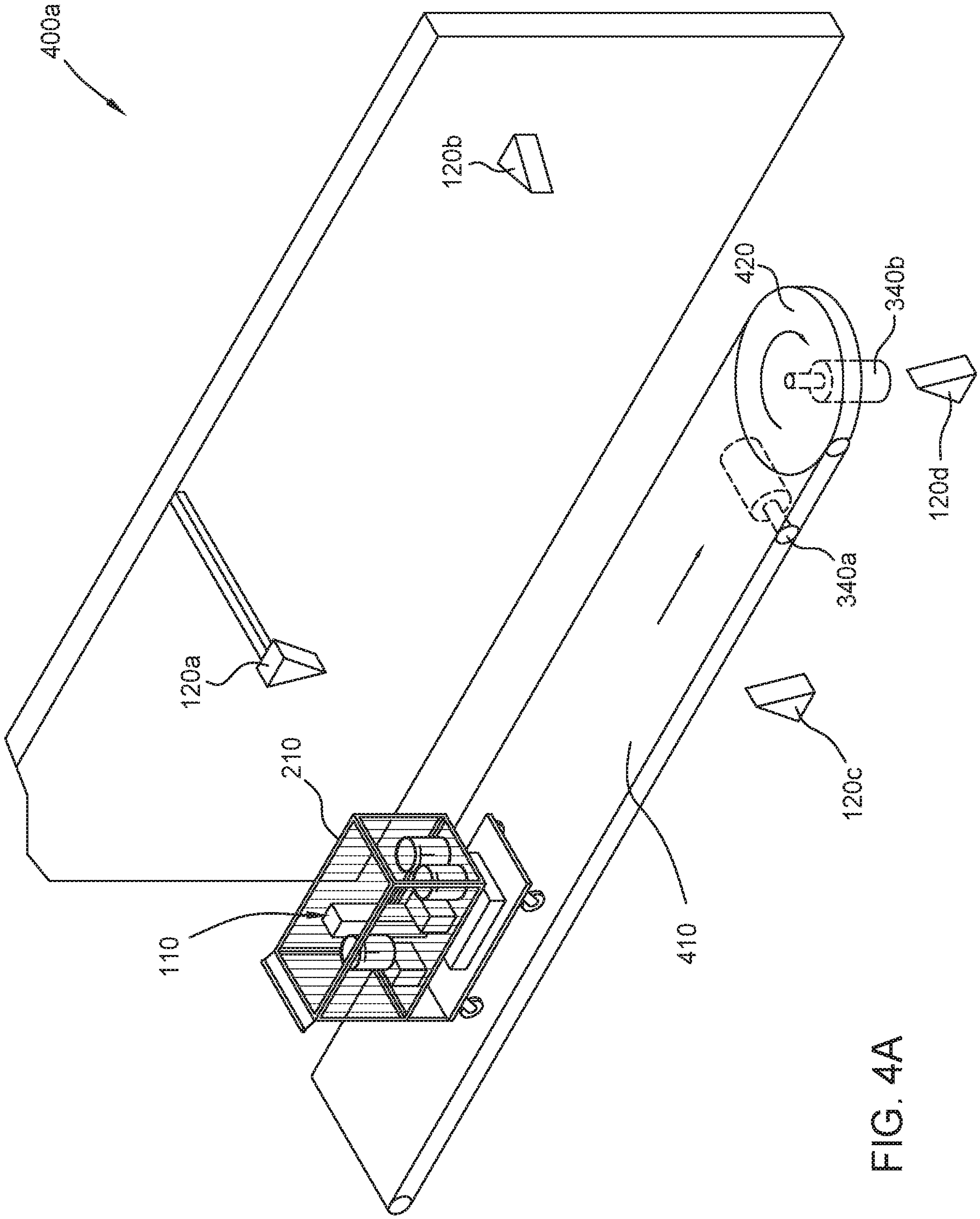


FIG. 4A

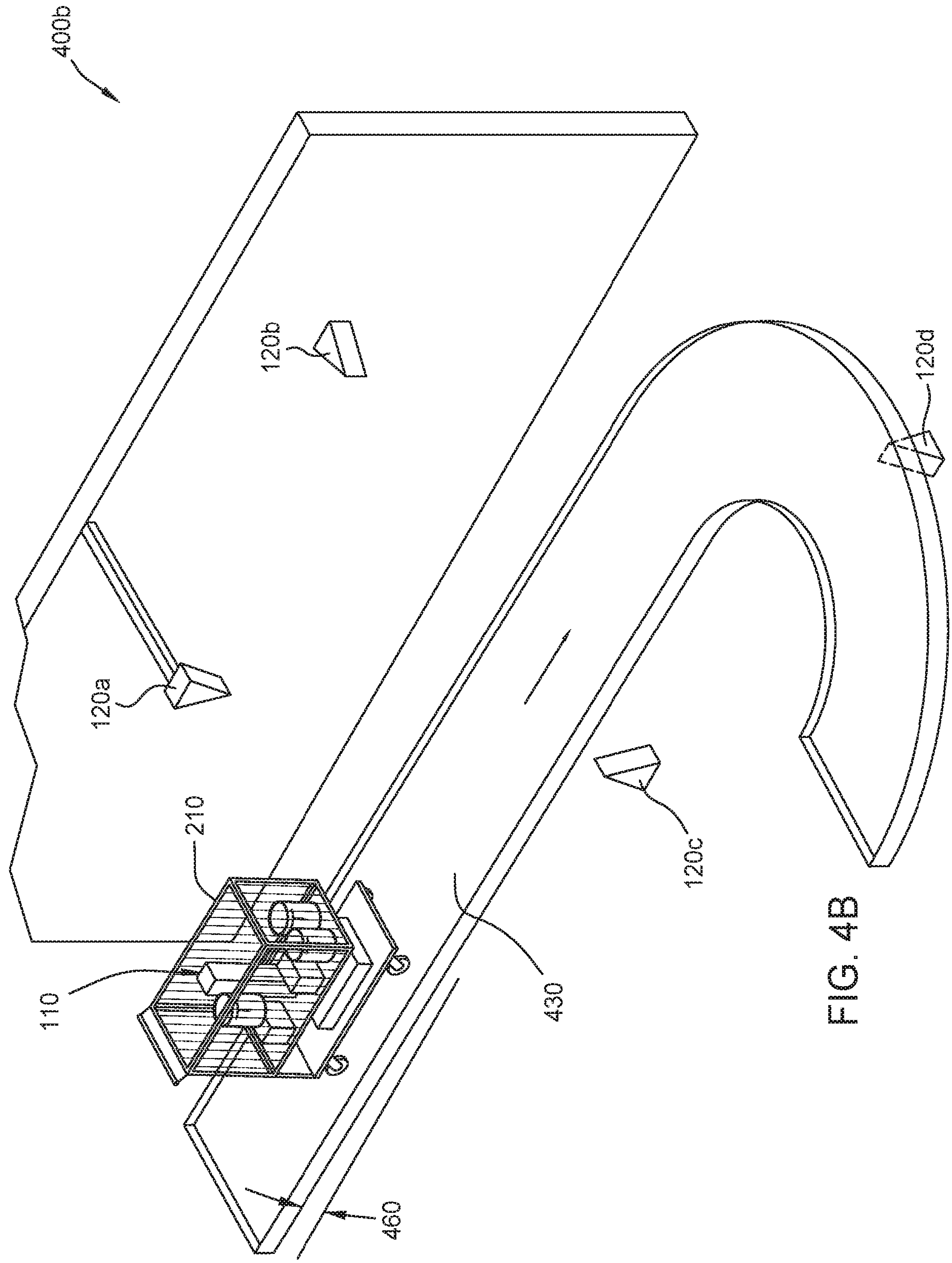


FIG. 4B

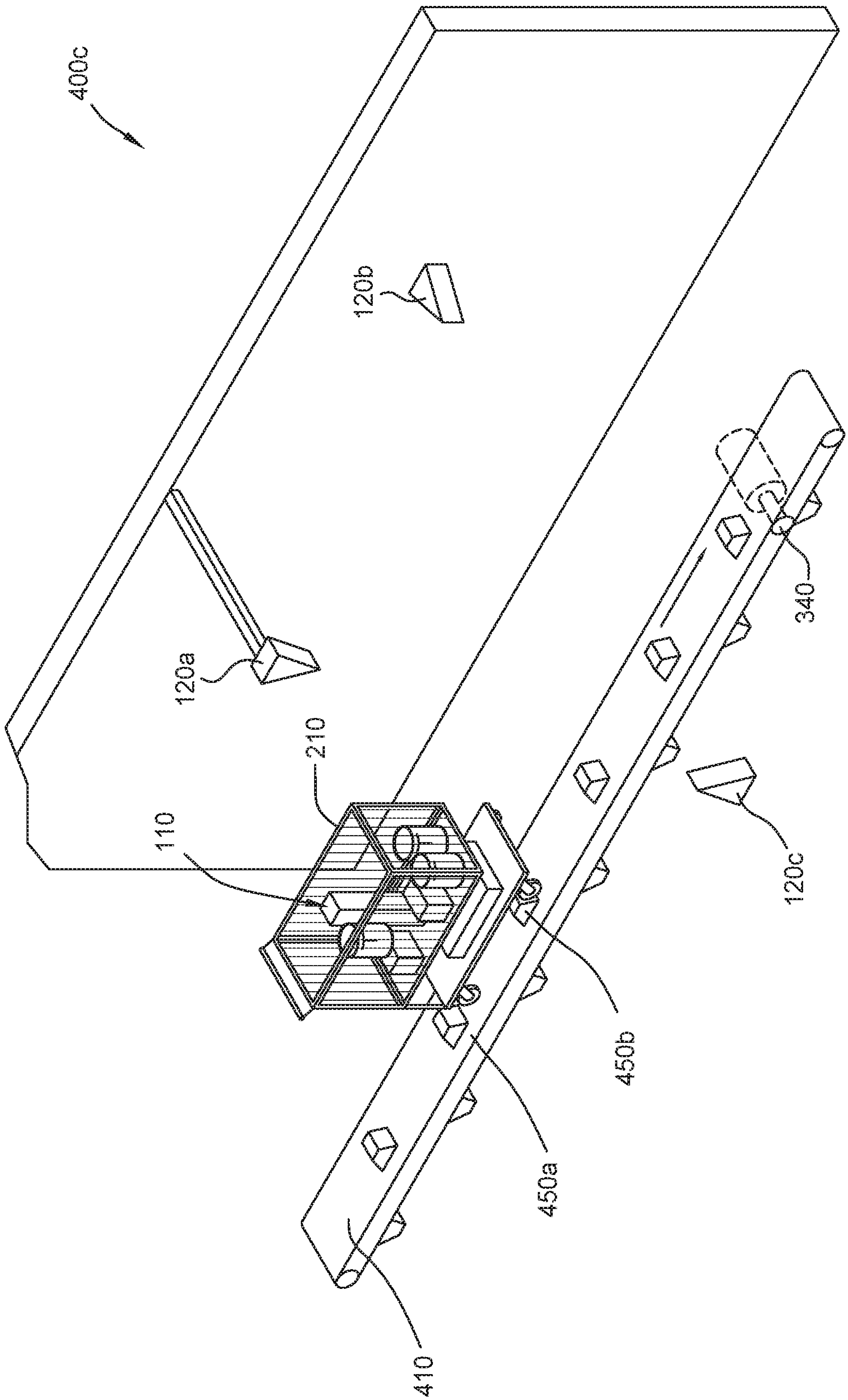


FIG. 4C

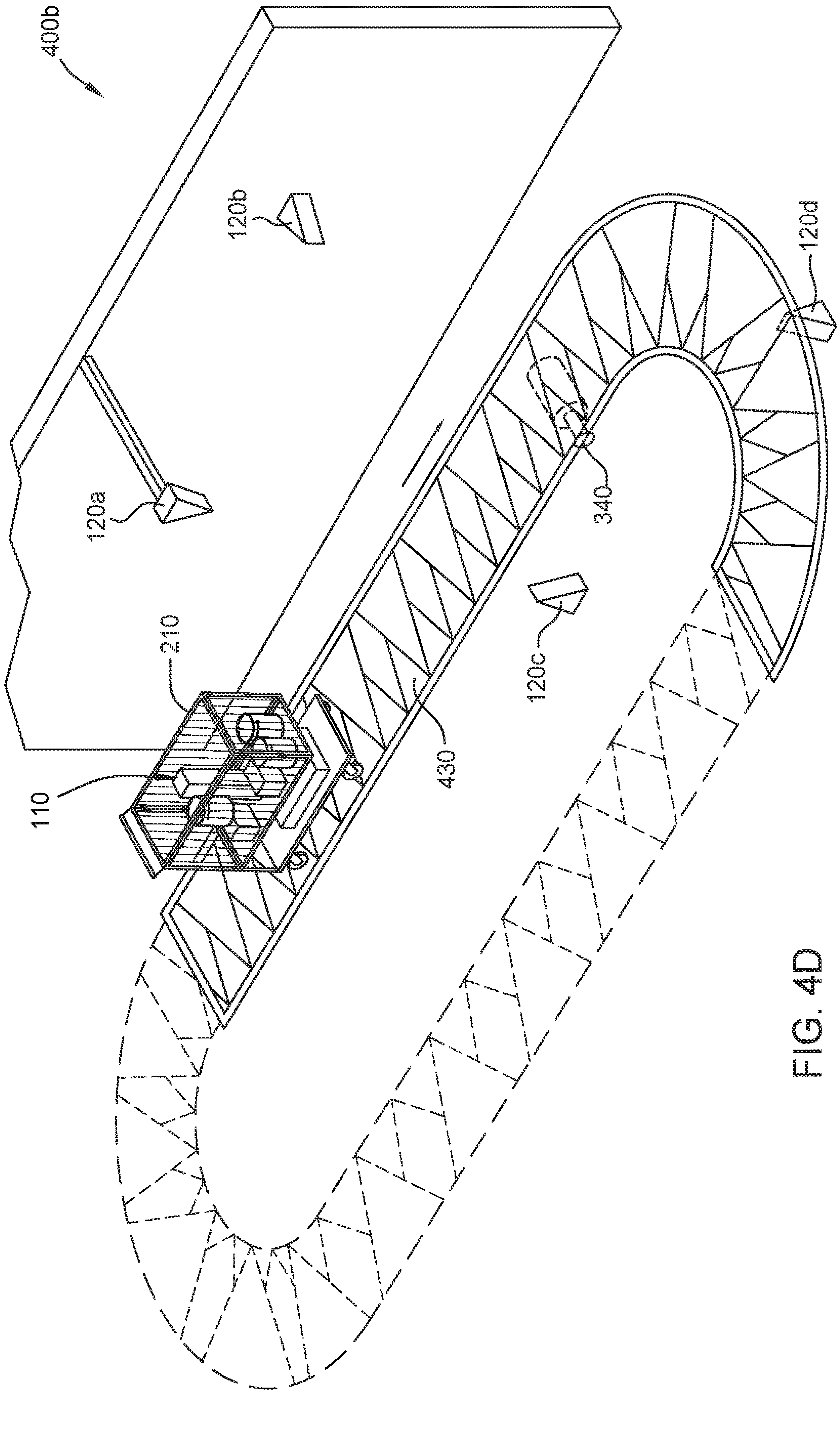


FIG. 4D

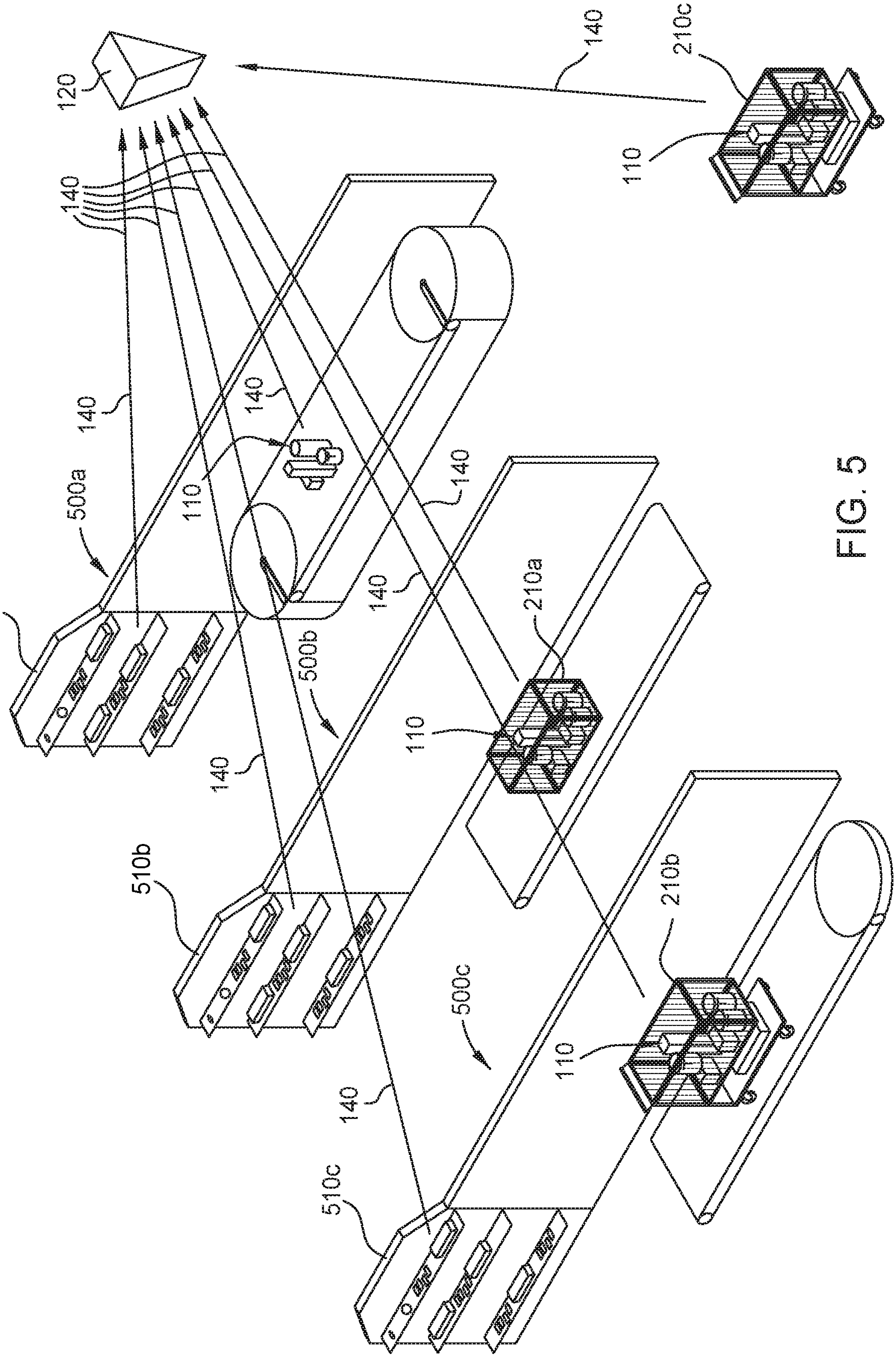

120
140
210c
110
140
140
110
140
500a
510a
140
210a
500b
110
140
510b
210b
500c
110
140
510c

FIG. 5

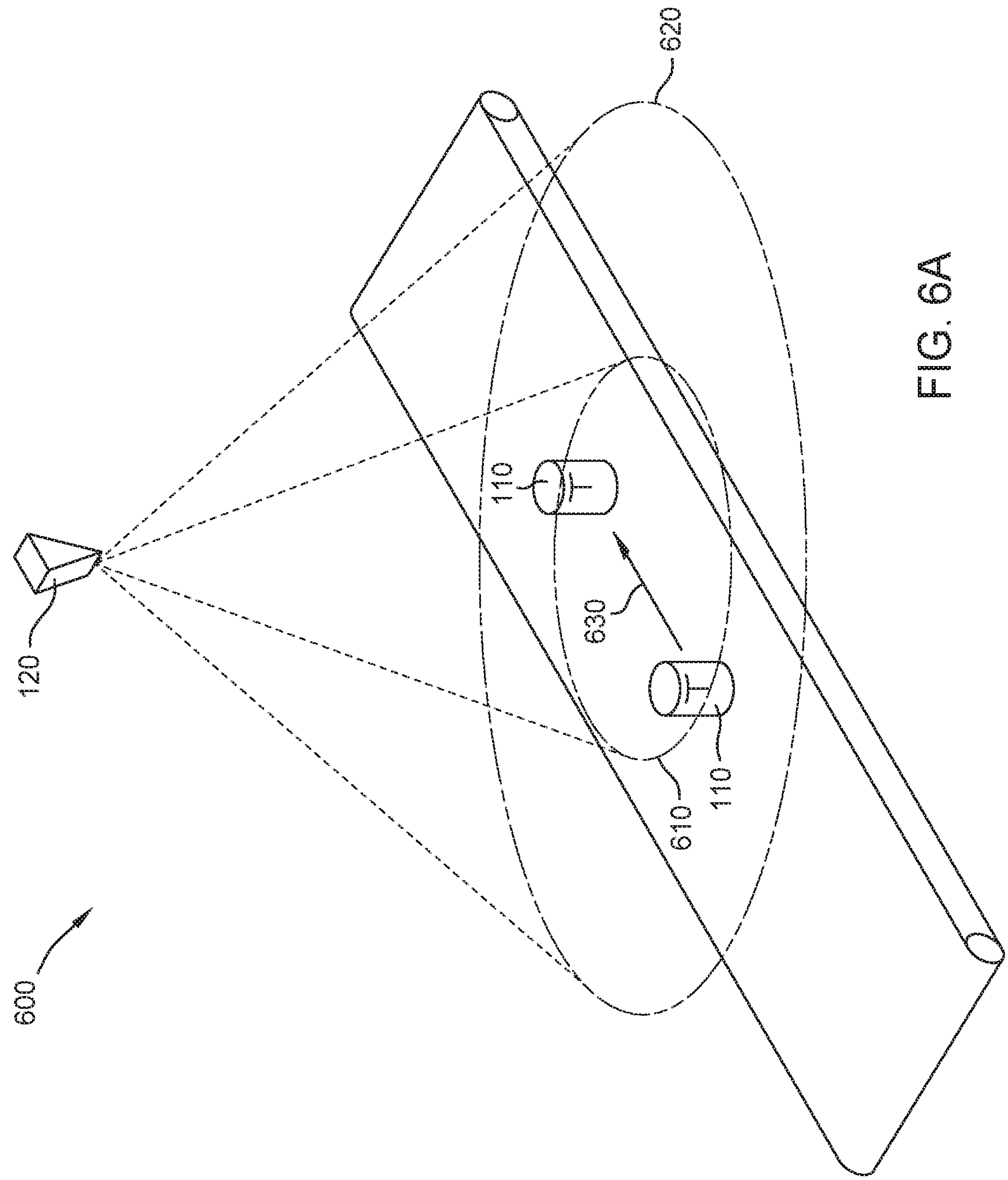


FIG. 6A

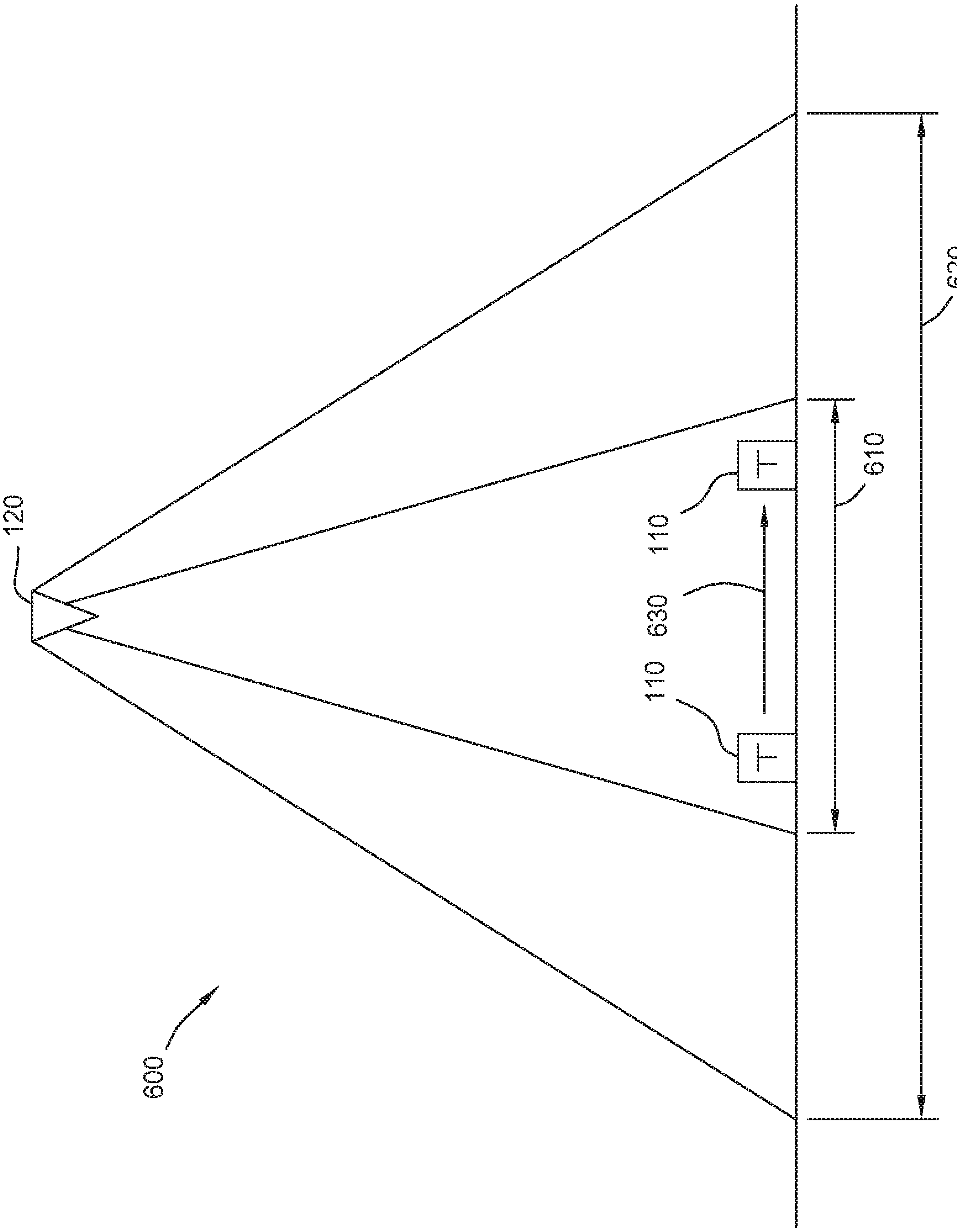


FIG. 6B

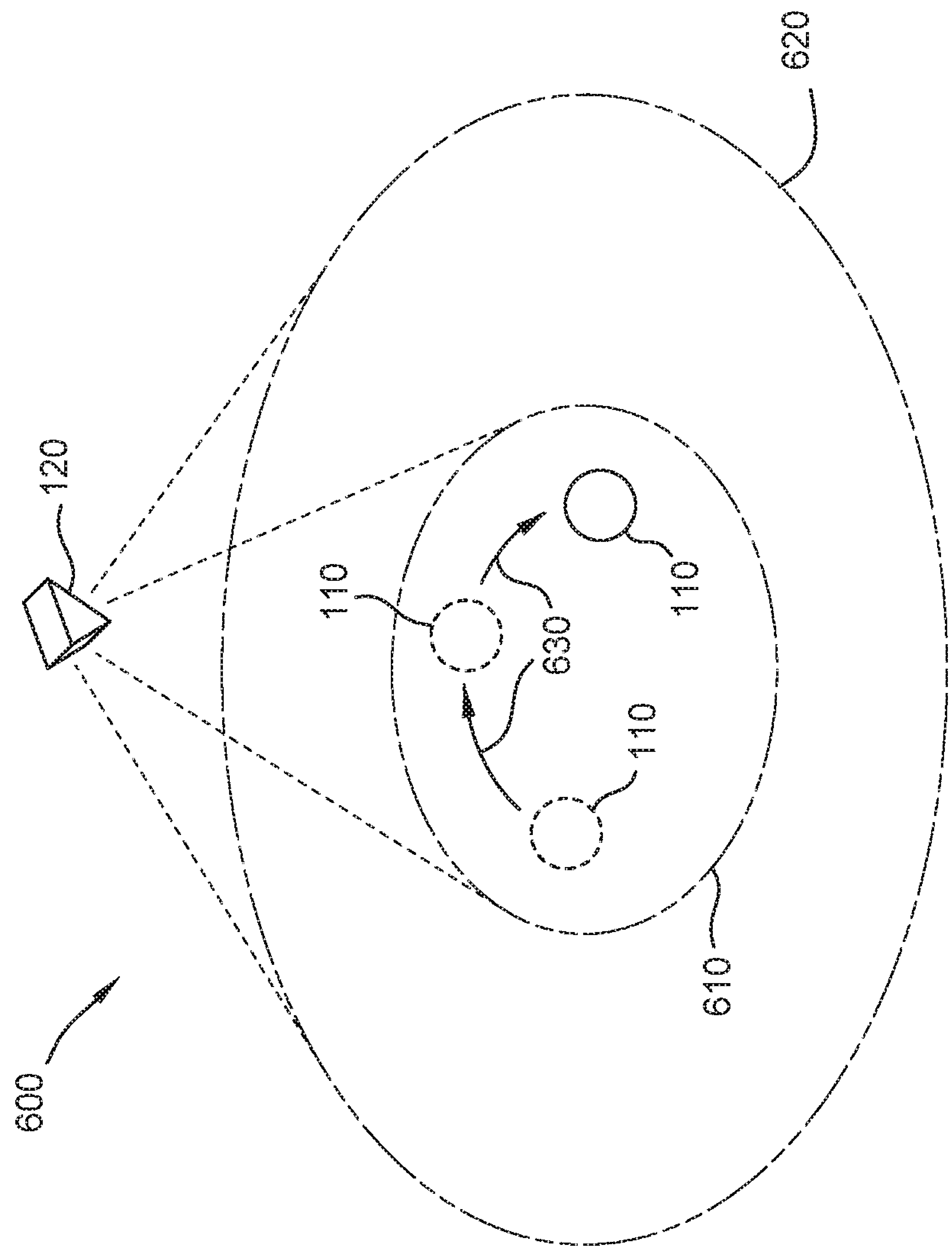


FIG. 6C

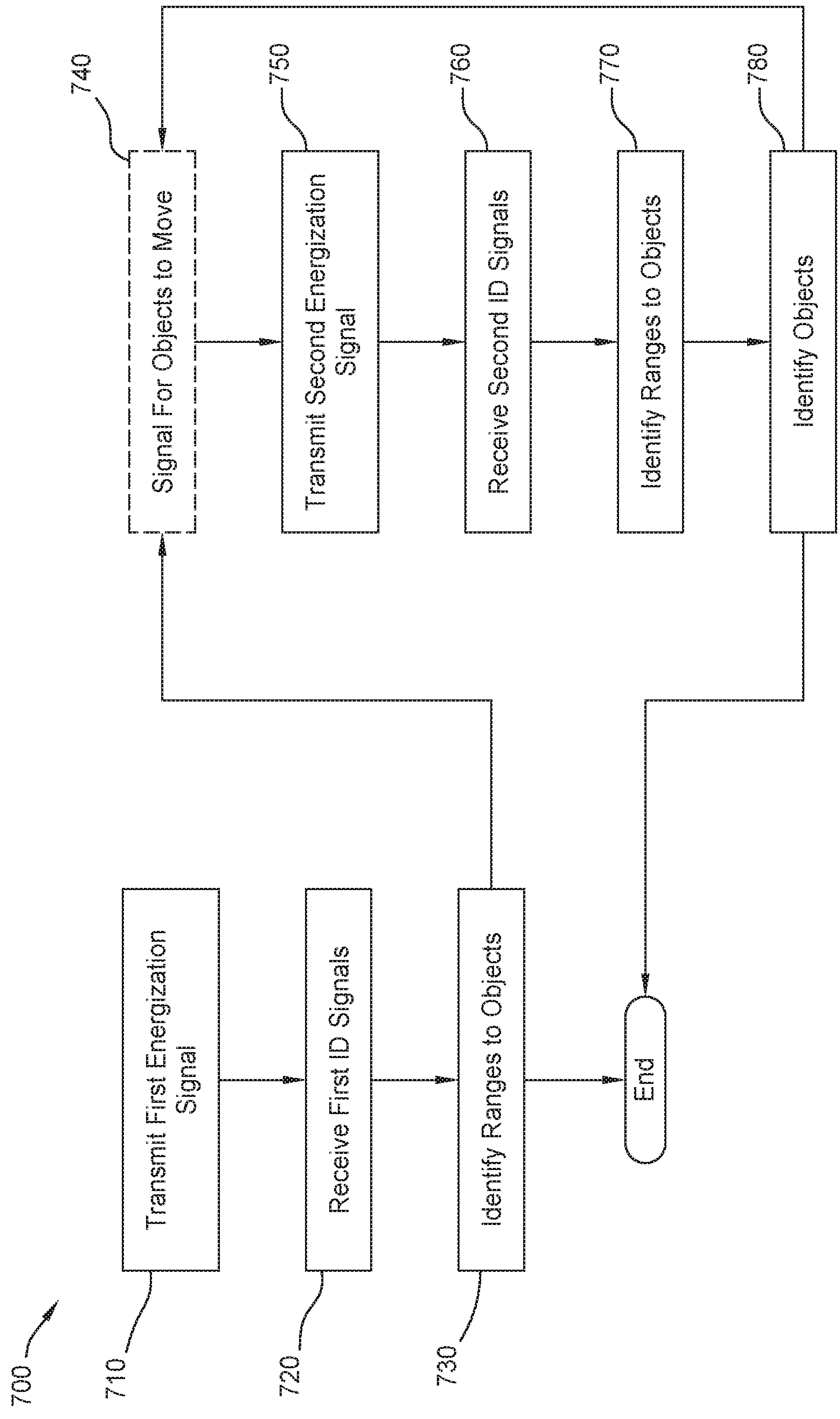

700
710
Transmit First Energization Signal
720
Receive First ID Signals
730
Identify Ranges to Objects
End
740
Signal For Objects to Move
750
Transmit Second Energization Signal
760
Receive Second ID Signals
770
Identify Ranges to Objects
780
Identify Objects

FIG. 7

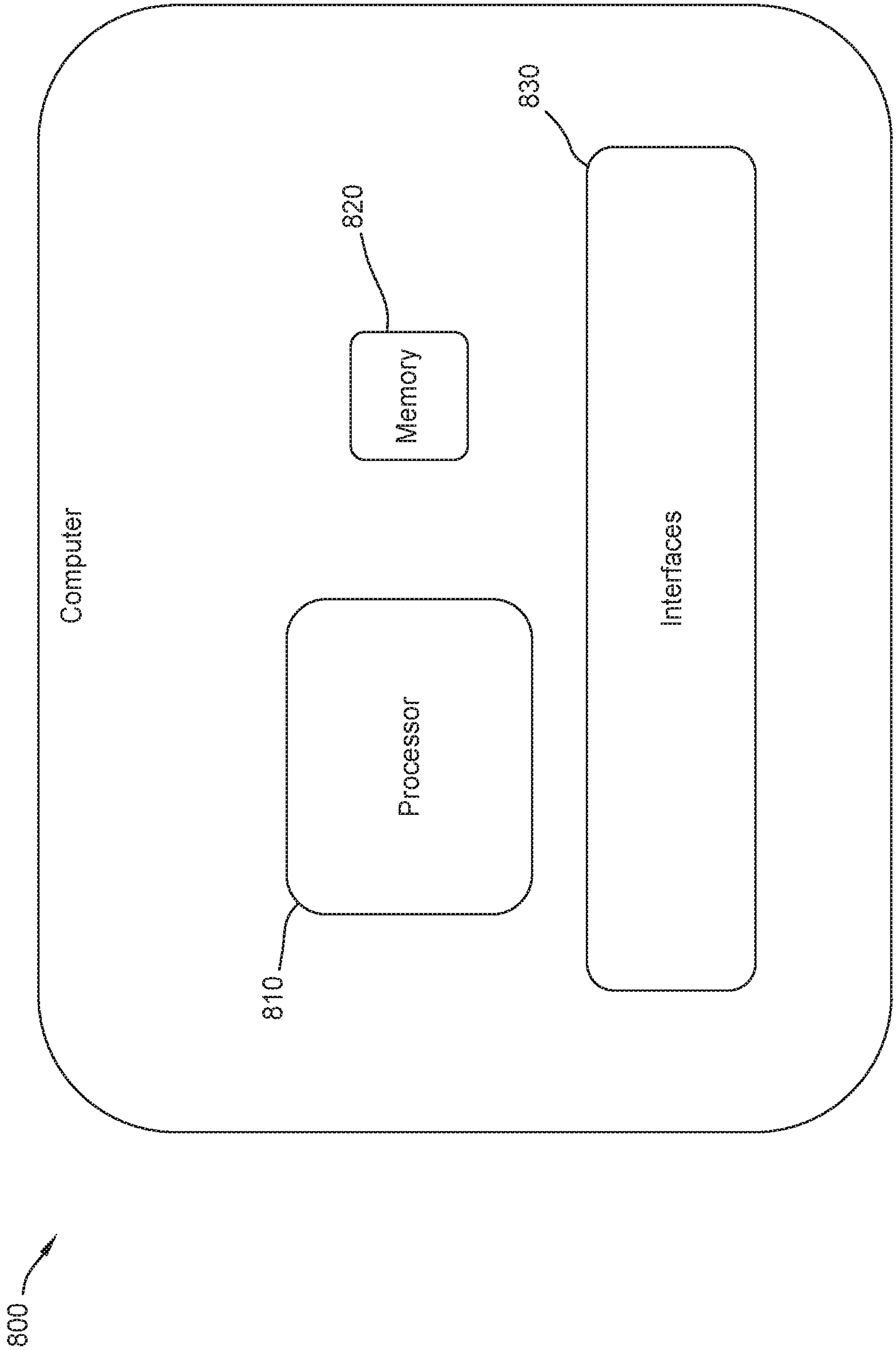


FIG. 8

RADIO FREQUENCY IDENTIFICATION IN SELF-CHECKOUT

BACKGROUND

The present invention relates to Radio Frequency Identification (RFID) and more specifically, to the improved deployment of RFID in self-checkout kiosks.

SUMMARY

According to one embodiment of the present invention, a system is provided that comprises: a first product pathway; a single Radio Frequency Identifier (RFID) antenna, having a first scanning zone aligned with the first product pathway; wherein the first product pathway is configured to: position a first set of objects within the first scanning zone at a first position relative to the single RFID antenna at a first time; and position the first set of object within the first scanning zone at a second position relative to the single RFID, different than the first position, at a second time; and wherein the single RFID antenna is configured to: receive, at the first time, a first set of identifier signals associated with at least some of the first set of objects; and receive, at the second time, a second set of identifier signals associated with at least some of the first set of objects.

According to one embodiment of the present invention, a kiosk is provided that comprises: a single RFID antenna, configured to project and receive signals relative to a first scanning zone; and a first motor, configured to move objects along a first product pathway relative to the single RFID antenna from a first position in the first scanning zone to a second position in the first scanning zone.

According to one embodiment of the present invention, a method is provided that comprises: transmitting, via a single RFID antenna, a first energization signal; receiving, by the single RFID antenna at a first time, a first set of identifier signals in response to the first energization signal; transmitting, via the single RFID antenna, a second energization signal; receiving, by the single RFID antenna at a second time, a second set of identifier signals in response to the second energization signal; and identifying objects associated with at least one of the first set of identifier signals and the second set of identifier signals and that moved relative to the single RFID antenna between the first time and the second time.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an RFID scanning arrangement, according to embodiments of the present disclosure.

FIGS. **2**A-**2**B illustrate relative repositioning in a bulk RFID scanning arrangement, according to embodiments of the present disclosure.

FIG. **3** illustrates counter-level pathways in a kiosk for RFID self-checkout, according to embodiments of the present disclosure.

FIGS. **4**A-**4**D illustrate floor-level pathways in a kiosk for RFID self-checkout, according to embodiments of the present disclosure.

FIG. **5** illustrates a checkout station including several kiosks for RFID self-checkout, according to embodiments of the present disclosure.

FIGS. **6**A-**6**C illustrate signaling zones of an RFID scanner, according to embodiments of the present disclosure.

FIG. **7** is a flowchart of a method for RFID scanning, according to embodiments of the present disclosure.

FIG. **8** illustrates a computing device, according to embodiments of the present disclosure.

DETAILED DESCRIPTION

Self-checkout is becoming an increasing popular method of processing transactions, but the technologies relied upon to identify items for checkout remain prone to error and the processes still require significant amounts of manual labor (e.g., having a patron use an optical scanner) and computing resources (e.g., for image recognition). RFID technologies offer benefits in accuracy and speed of self-checkout, while reducing demand for manual labor and computing resources compared to patron-performed barcode scanning or image recognition solutions, but are susceptible to errors from cross-interference (e.g., from nearby RFID signal sources) or shadowing (e.g., the occlusion or blocking of communications between scanner and tag) unless carefully managed. The present disclosure provides for the management of RFID scanning in self-checkout by providing for the coordinated use of several potentially interfering RFID signal sources and/or shadowed items by ensuring multiple scans of the items are performed by an RFID scanner when the items-to-scan are located at different locations relative to the RFID scanner. Stated differently, by enforcing rotation of a relative angle between an item and an RFID scanner during self-checkout, an RFID scanner can provide self-checkout with improved accuracy, speed, and computing efficiency.

FIG. **1** illustrates an RFID scanning arrangement, according to embodiments of the present disclosure. In the RFID scanning arrangement, an object **110** is provided with an RFID tag **111**, which interacts with an RFID antenna **120** to identify the object **110** associated with the RFID tag **111**. The RFID tag **111** includes a radio transponder that is triggered by an excitation signal **130** transmitted from the RFID antenna **120** to produce an identifier signal **140**. The identifier signal **140** include information about the object **110** associated with the RFID tag **111**, which can include an object-type identifier and/or a unique identifier for the given object **110**. For example, an object-type identifier can identify that the associated object **110** is a can of beans (rather than a can of corn, a tube of toothpaste, or a bag of beans), whereas unique identifiers can identify that the can of beans is a particular object **110** (e.g., can number X rather than can number Y).

FIGS. **2**A and **2**B illustrate relative repositioning in a bulk RFID scanning arrangement, according to embodiments of the present disclosure. Bulk scanning is the process when an RFID antenna **120** attempts to read several RFID tags **111** at the same time. Each object **110***a-d* is individually tagged with an associated RFID tag **110***a-d*, but due to the proximity of the objects **110** to one another, the various objects **110** can fully or partially block the excitation signal **130**, fully or partially block identifier signals **140**, and/or the various identifier signals **140** can interfere with one another.

Consider then the examples shown in FIGS. **2**A and **2**B in which a container **210** (e.g., a bag, box, shopping basket, buggy, cart, skid, hand truck, wagon, etc.) including four objects **110***a-d* (with associated RFID tags **111***a-d*) are subjected to bulk scanning. In FIG. **2**A, although the RFID antenna **120** has broadcast an excitation signal **130**, only a first identifier signal **140***a*, a third identifier signal **140***c*, and a fourth identifier signal **140***d* are transmitted back to the RFID antenna **120**; the first identifier signal **140***a* (associated with the first object **110***a*) is transmitted in an unintelligible state (e.g., below a threshold Signal to Noise Ratio (SNR) for the RFID antenna **120**, with garbled data, etc.), and a second identifier signal **140***b* (associated with the second object **110***b*) is not transmitted. For example, the third object **110***c* or the container **210** may shadow the first and second objects **110***a-b* in FIG. **2**A; blocking reception of the excitation signal **130** by the second objects **110***b* and blocking transmission of the first identifier signal **140***a*. Similarly, in FIG. **2**B, the RFID antenna **120** broadcasts an excitation signal **130**, but only receives a first identifier signal **140***a*, a second identifier signal **140***b*, and a third identifier signal **140***c*; the fourth identifier signal **140***d* is blocked from reaching the RFID antenna **120** (e.g., by the third object **110***c* and/or the container **210**).

However, between the examples shown in FIGS. **2**A and **2**B, the RFID antenna **120** has received identifier signals **140** associated with each of the objects **110** in the container **210**. Accordingly, by enforcing several readings of the objects **110** in a container **210** at several different relative angle to the RFID antenna **120**, the RFID antenna **120** can reliably and accurately scan large groups of object **110** (e.g., to track for inventory purposes). By enforcing different relative angles of the objects **110** to the RFID antenna **120**, negative arrangements of objects **110** can be mitigated with beneficial arrangements of objects **110**. Although generally discussed in terms of a first arrangement (at a first time and first location relative to the RFID antenna **120**) and a second arrangement (at a second time and second location relative to the RFID antenna **120**), the present disclosure can be applied to further arrangements (e.g., third, fourth, nth). Additionally, although the present disclosure generally provides examples related to groups of objects **110** held in containers **210**, it will also be appreciated that the present disclosure can be applied to individual objects **110** and loose collections of objects **110** (i.e., objects **110** not held in a container **210**, such as objects **110** removed from a container **210** and placed on a checkout conveyor or platform).

FIG. **3** illustrates counter-level pathways in a kiosk **300** for RFID self-checkout, according to embodiments of the present disclosure. The counter level pathways include elevated tracks that, when activated by an associated motor, move items placed thereon. As shown, the kiosk **300** includes a first carousel **310***a* that includes a first motor **340***a* to move/rotate a first rounded (e.g., circular, ovoid) track or platform, a second carousel **310***b* that includes a second motor **340***b* to move/rotate a second rounded track or platform, and a linear conveyor **320** that includes a third motor **340***c* to move a linear track or belt. The kiosk **300** includes a shield wall **330** located in a plane perpendicular to the plane of travel along the first carousel **310***a*, linear conveyor **320**, and/or second carousel **310***b* to block or attenuate excitation signals **130** and/or identifier signals **140** from one kiosk **300** being received at a different kiosk **300**. Shield walls **330** are discussed in greater detail in regard to FIG. **5**.

The linear conveyor **320** is shown between the first carousel **310***a* and the second carousel **310***b* so that items placed on the first carousel **310***a* rotate onto the linear conveyor **320**, which delivers the items to the second carousel **310***b*. In various embodiments, the linear conveyor **320** can be omitted, and items are placed onto a first carousel **310***a* and are transferred directly from the first carousel **310***a* to the second carousel **310***b*. In various embodiments, the linear conveyor **320** can include a linear belt that carries objects to different locations in the kiosk **300** when driven by the third motor **340***c*, but can also include various tracks (e.g., chain links) that are driven the by third motor **340***c*.

In some embodiments, the first carousel **310***a* may be placed in an unloading area of the kiosk **300** (e.g., for a patron to unload items from a container **210** onto the conveyors for checkout, for a patron to move items from one container **210** (e.g., a buggy) to another (e.g., bags or boxes for easy transport), etc.). In some embodiments, the first carousel **310***a* may be omitted or replaced with a stationary or non-motorized (e.g., human-powered) unloading area. In various embodiments, the first carousel **310***a* includes a round platform that, when driven by the first motor **340***a* rotates and carries items placed thereon in a circular (or ovoid) pattern.

In some embodiments, the second carousel **310***b* may be placed in a post-checkout loading area of the kiosk **300** (e.g., for a patron to unload items from the conveyors that have been purchased and into a container **210** for easy transport). Although illustrated as rotating in the same direction as the first carousel **310***a*, in various embodiments, the second carousel **310***b* can rotate in a different direction than the first carousel **310***a* (e.g., clockwise versus counterclockwise). In various embodiments, various bags, boxes, etc., may be provided at the post-checkout area for ease of transport of items marked as purchased. In some embodiments, the second carousel **320***a* may be omitted or replaced with a stationary or non-motorized (e.g., human-powered) unloading area. In some embodiments, the kiosk **300** can omit the first carousel **310***a* and the linear conveyor **320**; including only the second carousel **310***b*.

In various embodiments, the first carousel **310***a* and/or second carousel **310***b* include a round platform that, when driven by the respective motor **340**, rotates and carries items placed thereon in a circular (or ovoid) pattern. In some embodiments the first carousel **310***a* and/or second carousel **310***b* include an articulated track formed over a closed path that, when driven by the respective motor **340**, drives the articulated track in a circular (or ovoid) pattern and carried items placed thereon in the circular (or ovoid) pattern. In various embodiments, the first carousel **310***a* and/or the second carousel include a respective first blocker bar **311***a* or a second blocker bar **311***b* in the path of travel. The first blocker bar **311***a* prevents items placed on the first carousel **310***a* from making more than one circuit and to push those items (passively or actively) onto a next portion of the track in the kiosk **300**. The second blocker bar **311***b* prevents items placed on the second carousel **310***b* from making a full circuit and to avoid interfering with prior portions of the track in the kiosk **300** and/or to push those items (passively or actively) off of the second carousel **310***b* (e.g., into a waiting container **210**).

As items are placed onto the various tracks of the first carousel **310***a*, linear conveyor **320**, and/or second carousel **310***b*, one or more RFID antennas **120** can scan those items to identify which items are being carried through the kiosk **300**. In various embodiments, a single RFID antenna **120** is used in the kiosk **300**, which may be any of an above-track antenna **120***a*, a sub-track antenna **120***b*, or an angled antenna **120***c*. The motion imparted by the various tracks enable an RFID antenna **120** (whether singly or in conjunction with other RFID antennas **120**) to send excitation signals **130** to the items at different relative angles to the RFID antenna **120**, and to receive identifier signals **140** from the items at different relative angles to the RFID antenna **120** (e.g., moving one or more objects **110** or container **210** including one or more objects **110** from a first location to a second location as in FIGS. **2**A and **2**B).

An above-track antenna **120***a* describes an RFID antenna **120** that is part of the kiosk **300** (or otherwise associated with the kiosk **300**) that projects excitation signals **130** generally downward to a track (of one or more of the first carousel **310***a*, linear conveyor **320**, and/or second carousel **310***b*) that is located below the RFID antenna **120**.

A sub-track antenna **120***b* describes an RFID antenna **120** that is part of the kiosk **300** (or otherwise associated with the kiosk **300**) that projects excitation signals **130** generally upward to a track (of one or more of the first carousel **310***a*, linear conveyor **320**, and/or second carousel **310***b*) that is located above the RFID antenna **120**. Although illustrated as being incorporated in the linear conveyor **320**, a sub-track antenna **120***b* can also be incorporated into a carousel (e.g., the first carousel **310***a* or second carousel **310***b*).

An angled antenna **120***c* describes an RFID antenna **120** that is part of the kiosk **300** (or otherwise associated with the kiosk **300**) that projects excitation signals **130** generally laterally to a track (of one or more of the first carousel **310***a*, linear conveyor **320**, and/or second carousel **310***b*) that is located below or at the same level as the RFID antenna **120**.

Regardless of whether the kiosk uses a single RFID antenna **120** or several coordinated RFID antennas **120**, the kiosk **300** is able to position and reposition items at two or more times at different locations relative to the RFID antenna(s) **120** to identify various objects **110** that may have been shadowed by other items on the tracks, and thereby identify which objects **110** to include, to add to, or remove from an inventory (e.g., for a purchase and/or for restocking and inventory management).

FIGS. **4A-4D** illustrate floor-level pathways in a kiosk **400** for RFID self-checkout, according to embodiments of the present disclosure. In addition to raised tracks (e.g., as in the kiosk **300** discussed in relation to FIG. **3**), a kiosk **400** can define a pathway (mobile or stationary) that a container **210** (e.g., a shopping buggy, cart, skid, hand truck, wagon, etc.) can travel to reposition one or more objects **110** contained therein at different relative angles to one or more RFID antennas **120** associated with the kiosk **400**.

Similarly to raised pathways, kiosks **400** with floor-level pathways can include a shield wall **330** that blocks physical and/or electromagnetic access to the pathway of the kiosk **400** in at least one plane (while leaving the pathway accessible in other planes). Additionally, one or more RFID antennas **120** can be positioned in a kiosk **400** with a floor-level pathway, including any of an above-track antenna **120***a*, a sub-track antenna **120***b*/**120***d*, or an angled antenna **120***c*. The motion imparted by the various tracks enable an RFID antenna **120** (whether singly or in conjunction with other RFID antennas **120**) to send excitation signals **130** to the items at different relative angles to the RFID antenna **120**, and to receive identifier signals **140** from the items at different relative angles to the RFID antenna **120** (e.g., moving one or more objects **110** or container **210** including one or more objects **110** from a first location to a second location as in FIGS. **2**A and **2**B).

FIG. **4**A illustrates an example motorized pathway for use in a kiosk **400** for RFID-based self-checkout. Similarly to the raised track pathway in FIG. **3**, the floor-level pathway in FIG. **4**A can include one or more of a linear conveyor **410** and a carousel **420**.

The linear conveyor **410** incudes a first motor **340***a* that drives a track or belt that, when engaged, moves any item placed thereon from a first side to a second side of the kiosk **400**. In various embodiments, the linear conveyor **410** is configured to allow a person to walk or stand thereon in addition to a container **210** and/or one or more object **110**. One or more sub-track antennas **120***b* can be positioned at various locations along the linear conveyor **410** between the loops of belts/tracks or under the looped belt/track.

The carousel **420** includes a second motor **340***b* to move/rotate a rounded (e.g., circular, ovoid) track or platform. When engaged, the carousel **420** rotates any item placed thereon, which can include one or more full rotations (i.e., rotation having a multiple of 360 degrees) and/or partial rotations (e.g., a rotation of less than 360 degrees). In various embodiments, the carousel **420** is configured to allow a person to walk or stand thereon in addition to a container **210** and/or one or more object **110**. One or more sub-track antennas **120***d* can be deployed at various positions under the track/platform of the carousel **420**.

In embodiments including both a linear conveyor **410** and a carousel **420**, the rotating platform of the carousel **420** can be positioned over the belt or track of the linear conveyor **410** (as is illustrated in FIG. **4**A), or the linear conveyor **410** and the carousel **420** can be positioned with a gap between one another.

FIG. **4**B illustrates an example gravity-assisted pathway for use in a kiosk **400** for RFID-based self-checkout. A trackway **430** that includes one or more of a linear section and a curved section are positioned at an angle **460** relative to a level floor so that an object **110** or container **210** placed at a first end of the trackway **430** will roll or slide to a second end. Accordingly, the one or more objects **110** placed on the trackway **430** are induced via gravity to move to different locations on the trackway **430** relative to the one or more RFID antennas **210** associated with the kiosk **400**.

FIG. **4**C illustrates an example chocked pathway for use in a kiosk **400** for RFID-based self-checkout. In various embodiments, a chocked linear conveyor **450***a* includes one or more chocks **450***b*. The chocks **450***b* are spaced at intervals along the chocked linear conveyor **450***a* and are configured to engage with a portion of a container **210** (e.g., one or two wheels on a shopping cart) to move that container **210** from a first position to a second position in the kiosk **400**. In various embodiments, the chocks **450***b* can occupy some or all of the width of the chocked linear conveyor **450***a*. In various embodiments, the chocked linear conveyor **450***a* includes an un-chocked portion configured to allow a person to stand on to thereby be conveyed from a first side of the kiosk **400** to a second side. In some embodiments, the chocked linear conveyor **450***a* is positioned next to a non-motorized walkway provided for a person to walk behind or to the side of the container **210** as the chocked linear conveyor **450***a* moves the container **210** from a first side of the kiosk **400** to a second side.

FIG. **4**D illustrates an example articulated pathway for use in a kiosk **400** for RFID-based self-checkout. The articulated pathway **440** is composed of several overlapping scales that articulate to slide over or under one another over a circular or ovoid pathway, when driven by an associated motor **340**. In various embodiments, the articulated pathway **440** is partially exposed (as is illustrated in FIG. **4**D) to define linear and curved sections or can be fully exposed to define a circular or ovoid path.

FIG. **5** illustrates a checkout station **500** including several kiosks for RFID self-checkout, according to embodiments of the present disclosure. The kiosks included in the checkout station **500** can include variants of the kiosks **300** and **400** discussed in relation to FIGS. **3** and **4A-4**D, as well as other kiosks (e.g., staffed kiosks, barcode antenna based self-checkout kiosks, camera and/or computer vision based shelf-checkout kiosks, etc.).

The checkout station **500** is generally positioned in a threshold of a building so that objects located inward relative to the checkout station **500** are considered part of the stock or inventory of the building, while objects located outward relative to the checkout station are considered part of the stock or inventory of a third party (e.g., purchased items, items brought for delivery). To make full use the threshold space, a proprietor can group several kiosks at the threshold, but by having several kiosks in close proximity, signals generated by one kiosk can interfere with signals generated by the other kiosks.

The RFID antenna **120** illustrated in the checkout station **500** may be associated with any one of the kiosks or may be a master-antenna associated with more than one kiosk. Due to the proximity of the kiosks, the RFID antenna **120** is (intentionally and/or unintentionally) able to send excitation signals **130** to and/or receive identifier signals **140** from objects **110** located in more than one kiosk and/or outside of the kiosks. To reduce the likelihood of the RFID antenna **120** interfering with or receiving interference from another RFID antenna **120**, and to differentiate objects **110** located in different kiosks, one or more strategies can be exercised in a checkout station **500**.

In some embodiments, the shield walls **330** of the individual kiosks can help the proprietor group the kiosks closer to one another by reducing the signal strength of generated excitation signals **130** received from the RFID antennas **120** associated with other kiosks and/or by reducing the signal strength of generated identifier signals **140** received from the tags **111** of objects **110** located in other kiosks and/or outside of the kiosks. In some embodiments, the shield walls **330** are made of materials that are radio opaque in the frequencies used for RFID scanning, so that any RFID signal that is received by the shield wall **330** is reflected away from an adjacent kiosk and/or is attenuated to reduce the strength of that signal.

The shield walls **330** are constructed in a plane perpendicular to the path of travel through the kiosk (whether elevated as in FIG. **3** or floor-level as in FIGS. **4**A-**4**D) while still allowing access to the path of travel. For example, a shield wall **330** may be constructed in a first plane (e.g., "behind" a plane in which the user loads the tracks from and perpendicular to a path of travel), but allows access to the path of travel in at least one other plane. When several kiosks are grouped together into a checkout station **500**, the shield walls **330** of adjacent kiosks can help contain and/or block RFID signals in the individual kiosks.

In addition to the shield walls **330**, several kiosks can be in communication with one another to share information related to scanned items to avoid identifying an item scanned at one kiosk as also being scanned at another kiosk. For example, a first kiosk can scan an item with a unique identifier associated therewith and identify that unique item to the other kiosks, so that if an RFID antenna **120** associated with another kiosk also received an identifier signal **140** carrying the unique identifier, the other kiosk can ignore that identifier signal **140** or otherwise not treat that item as being scanned at the associated kiosk. Stated differently, by knowing that another kiosk has already scanned an item, a kiosk can know not to treat that item as being scanned locally.

In various embodiments, the RFID antennas **120** associated with the kiosks can perform various distance measurements to determine whether a given identifier signal **140** (and therefore a given tag **111** and object **110**) is located within the kiosk or a designated sub-region (e.g., a scanning zone **610**, such as discussed in greater detail in regard to FIG. **6**A-**6**C) of the kiosk. When a distance to the item is outside of the kiosk or designated sub-region, the RFID antenna **120** can ignore that item or otherwise not include the item in a transaction. For example, items located inward from the threshold relative to the kiosk can be ignored as being part of an inventory and items located outward from the threshold relative to the kiosk can be ignored as being part of a completed transaction. Furthermore, the RFID antenna **120** can use the distance measurements to identify stationary objects that are not part of a checkout transaction, but may be present in the kiosk. For example, the endcaps **510***a-c* or in-aisle shelves (often offering candy, snacks, novelties, staple items, etc.) can include several items that receive excitation signals **130** and produce identifier signals **140** that the RFID antenna **120** ignores unless the items are identified as moving along the path of travel and/or in a designated sub-region of the kiosk.

FIGS. **6**A-**6**C illustrate signaling zones of an RFID antenna **120**, according to embodiments of the present disclosure. FIG. **6**A illustrates an isometric view of an object **110** being scanned by an RFID antenna **120** when traveling through the scanning pathway of a kiosk. In various embodiments, the RFID antenna **120** emits excitation signals **130** in various defined ranges, which can include the overall, maximum, or total signaling range **620** and a scanning zone **610**. The signaling range **620** describes the range from the RFID antenna **120** at which the excitation signal **130** has sufficient strength to induce a tag **111** to generate an identifier signal **140** with sufficient strength to be interpreted by the RFID antenna **120** on receipt, and may extend outside of the kiosk. In contrast, the scanning zone **610** is a subset of the signaling zone **620** that is confined to the path of travel through the associated kiosk. In various embodiments, the scanning zone **610** is defined as a predefined distance from the RFID antenna **120**, and the RFID antenna **120** is aligned with the path of travel through the kiosk to position the scanning zone **610** over some or all of the path of travel.

When an object **110** travels through the scanning zone **610**, the RFID antenna **120** receives multiple identifier signals from the RFID tag **111** associated with the object **110** at multiple positions from within the scanning zone **610** at corresponding times. Depending on the layout of the pathway, the presence of other objects **110** and/or funneling elements (e.g., bumpers, blocker bars **311**) in the pathway, a given object **110** can travel along various trajectories. For example, when an object **110** travels on a linear pathway, as is shown in FIG. **6**B, the object **110** moves from a first position (at a first time) to a second position (at a second time) and can produce a first identifier signal **140***a* and a second identifier signal **140***b* and the associated positions that the RFID antenna **120** can receive to track the object **110** through the scanning zone **610**. In another example, when an object **110** travels on a curved pathway (e.g., on a carousel or a curved track), as is shown in FIG. **6**B, the object **110** moves in a curved trajectory to be located at a first position (at a first time) to a second position (at a second time) and to a third position (at a third time) that reposition the object **110** to provide different surfaces towards the RFID antenna **120**. By reorienting the object **110** to the RFID antenna **120**, a curved trajectory can expose the object **110** from behind other objects **110**, face an RFID tag **111** towards the RFID antenna **120** and generally provide different transmission conditions for RFID signaling, and thus ensure more opportunities for the RFID antenna **120** to identify the object **110**.

In various embodiments, the RFID antenna **120** can define several different and/or overlapping scanning zones **610** with known distances and/or locations to further aid in processing objects **110** in a kiosk. In some embodiments, the kiosk includes several RFID antennas **120** that each define different scanning zones **610** for different purposes in processing objects in a kiosk. For example, a supplemental scanning zone **610** can be identified as a return zone, so that an object **110** unintentionally scanned can be removed from a transaction. In a further example, a supplemental scanning zone **610** can be used to identify when an item has entered the kiosk so that any motors **340** associated with the pathway(s) are activated to move objects through the kiosk and are deactivated when objects are not located in the kiosk.

FIG. **7** is a flowchart of a method **700** for RFID scanning, according to embodiments of the present disclosure. Method **700** begins at block **710**, where a first RFID antenna transmits a first energization signal. In various embodiments, the RFID antenna transmits the first energization signal at a known rate (e.g., every 500 ms).

At block **720**, the RFID antenna receives a first set of one or more identifier signals generated by RFID tags (associated with one or more objects) in response to the first energization signal. This first set of one or more identifier signals is received at a first time, when the objects are located at a first location (e.g., at an unloading side of a checkout kiosk).

At block **730**, the RFID antenna identifies the ranges to the objects from which the identifier signals were received in block **720**. When the ranges to the objects are outside of the scanning zone of the RFID antenna (e.g., the objects are located in a different kiosk or outside of the kiosk), method **700** can conclude. When the ranges to the objects indicated that the objects are within the scanning zone of the RFID antenna, method **700** proceeds to block **740**. In various embodiments, the ranges to the objects can be determined based on one or more of: a signal strength of the identifier signal, a time of flight between when the excitation signal was generated and the identifier signal received, a phase of the identifier signal, etc.

At block **740**, the RFID antenna optionally signals for the object identified as in-range in block **730** to move through the kiosk. In various embodiments, the RFID antenna can activate a motor associated with a track in the kiosk (e.g., a carousel, a linear conveyor) and/or signal a human operator to proceed with checkout (e.g., an audio signal to "please place your basket on the conveyor when ready"). In some embodiments, block **740** can be omitted if the kiosk includes a passive movement system for the objects placed therein (e.g., a sloped pathway), an operator powered movement system (e.g., a manually rotated carousel), or a motorized movement system that is controlled by a means other than an RFID antenna (e.g., a switch, an optical scanner, a pressure plate) or that is "always on".

At block **750**, the RFID antenna transmits a second energization signal at a later time than the first energization signal, and at block **760**, the RFID antenna receives a second set of one or more identifier signals generated by RFID tags (associated with one or more objects) in response to the second energization signal. This second set of one or more identifier signals is received at a second time, when the objects are located at a second location.

At block **770**, the RFID antenna identifies the ranges to the objects from which the identifier signals were received in block **760**. In various embodiments, the ranges to the objects can be determined based on one or more of: a signal strength of the identifier signal, a time of flight between when the excitation signal was generated and the identifier signal received, a phase of the identifier signal, etc.

At block **780**, the RFID antenna (or a computing device associated with one or more RFID scanners) determines which objects to include in an ongoing transaction based on which objects associated with at least one of the first set of identifier signals and the second set of identifier signals have moved relative to the RFID antenna between the first time and the second time.

In various embodiments, when the RFID antenna determines that an object has not moved between the first and second times (e.g., the ranges in block **730** and **740** are the same), the RFID antenna ignores any identifier signals received from that object. For example, the RFID antenna could detect a candy bar located in an endcap or shelf associated with the kiosk that remains stationary because the customer has not chosen to remove the candy bar from the shelf and purchase it. In a further example, a customer may be in the process of unloading a shopping cart, and until the object is placed on a conveyor or carousel, could elect not to purchase that object. In an additional example, an object that has passed through the kiosk and is loaded into a cart to transport away from the kiosk may remain stationary as other objects are scanned.

When an object has moved within the scanning zone between the first time and the second time, the RFID antenna can add that item to an ongoing transaction. The RFID antenna, however, can ignore objects seen multiple times and that are already part of the ongoing transactions (e.g., based on a unique identifier included in the identifier signal).

Method **700** may return to block **740** to optionally continue scanning additional objects at subsequent times and additional positions relative to the RFID antenna, or may conclude. On conclusion of method **700**, a customer may be prompted to confirm the objects identified in method **700** and complete the transaction.

FIG. **8** illustrates a computing device **800**, according to embodiments of the present disclosure. The computing device **800** includes a processor **810**, a memory **820**, and an interface **830**, and may include other components such as a microphone, a speaker, a power supply, additional storage, additional input devices, and additional output devices. The computing device **800** is generally under the control of an operating system (not shown). The processor **810** is included to be representative of a single CPU (central processing unit), multiple CPUs, a single CPU having multiple processing cores, and the like

The memory **820** may be a persistent or a volatile storage device. Although the memory **820** is shown as a single unit, the memory **820** may be a combination of fixed and/or removable non-transient computer readable memory storage devices, such as fixed disc drives, solid state drives, SAN storage, NAS storage, removable memory cards or optical storage. The memory **820** may be part of one virtual address space spanning multiple primary and secondary storage devices.

As shown, the memory **820** includes various applications **823** (including Operating Systems for the computing device **800**).

The interfaces **830** may be any type of device to manage input to or output from the computing device **800** and can include connections to the RFID antenna **120** signal when to generate excitation signals **130**, and to receive and interpret identifier signals **140**. The interfaces **830** can also include direct or networked connected to/from various inventory control systems, point of sale (POS) terminals, and to enable the computing device **800** to communicate with other computers (e.g., NFC scanners, WiFi antennas, cell antennas, Ethernet ports, Bluetooth antennas, etc.).

The descriptions of the various embodiments of the present invention have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

In the following, reference is made to embodiments presented in this disclosure. However, the scope of the present disclosure is not limited to specific described embodiments. Instead, any combination of the following features and elements, whether related to different embodiments or not, is contemplated to implement and practice contemplated embodiments. Furthermore, although embodiments disclosed herein may achieve advantages over other possible solutions or over the prior art, whether or not a particular advantage is achieved by a given embodiment is not limiting of the scope of the present disclosure. Thus, the following aspects, features, embodiments and advantages are merely illustrative and are not considered elements or limitations of the appended claims except where explicitly recited in a claim(s). Likewise, reference to "the invention" shall not be construed as a generalization of any inventive subject matter disclosed herein and shall not be considered to be an element or limitation of the appended claims except where explicitly recited in a claim(s).

Aspects of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system."

The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

The computer readable storage medium can be any tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A system, comprising:

a first product pathway in a self-checkout kiosk;

a single Radio Frequency Identifier (RFID) antenna in the self-checkout kiosk, having a first scanning zone aligned with the first product pathway;

wherein the first product pathway is configured to:

position a first set of objects within the first scanning zone at a first position relative to the single RFID antenna at a first time; and

position the first set of objects within the first scanning zone at a second position relative to the single RFID, different than the first position, at a second time; and

wherein the single RFID antenna is configured to:

receive, at the first time, a first set of identifier signals associated with at least some of the first set of objects;

receive, at the second time, a second set of identifier signals associated with at least some of the first set of objects;

responsive to determining at least some of the first set of objects are detected in both the first and second set of identifier signals, determine whether the at least some of the first set of objects have been added to a transaction at the self-checkout kiosk; and

responsive to determining that the at least some of the first set of objects have not been added, add the at least some of the first set of objects to the transaction.

2. The system of claim **1**, wherein the single RFID antenna is further configured to:

identify objects from the first set of objects identified in at least one of the first set of identifier signals and in the second set of identifier signals via unique identifiers.

3. The system of claim **1**, further comprising:

a second RFID antenna, having a second scanning zone aligned with the first product pathway;

wherein the second RFID antenna is configured to:

receive, at the first time, a third set of identifier signals associated with at least some of the first set of objects;

receive, at the second time, a fourth set of identifier signals associated with at least some of the first set of objects; and

coordinate with the single RFID antenna to identify objects from the first set of objects identified in at least one of the first set, second set, third set, and fourth set of identifier signals via unique identifiers associated with each object in the first set of objects.

4. The system of claim **1**, further comprising:

a second RFID antenna, having a second scanning zone aligned with the first product pathway, wherein the second scanning zone is different from the first scanning zone;

wherein the second RFID antenna is configured to:

receive, at the first time, a third set of identifier signals associated with at least some of a second set of objects;

receive, at the second time, a fourth set of identifier signals associated with at least some of the second set of objects; and

coordinate with the single RFID antenna to identify objects from the first set of objects identified in at least one of the first set and second set of identifier signals that are also identified in at least one of the third set and fourth set of identifier signals and remove objects belonging to the second set of objects from the first set of objects via unique identifiers associated with each object in the first set of objects.

5. The system of claim **1**, further comprising:

radio frequency shielding disposed in a first plane perpendicular to a second plane of travel of the first product pathway.

6. The system of claim **1**, wherein the first product pathway includes at least one of:

a motorized carousel track;

a motorized linear track;

a chock-assisted linear track;

a gravity-assisted linear track; and

a gravity-assisted curved track.

7. The system of claim **1**, wherein the first scanning zone of the single RFID antenna is included within a signaling range of the single RFID antenna with a greater area than the first scanning zone, wherein objects identified in the signaling range are not identified as being part of the first set of objects unless having also been identified within the first scanning zone.

8. A self-checkout kiosk, comprising:

a first RFID antenna, configured to project and receive signals relative to a first scanning zone;

a first motor, configured to move objects along a first product pathway relative to the first RFID antenna from a first position in the first scanning zone to a second position in the first scanning zone;

a second RFID antenna, configured to project and receive signals relative to a second scanning zone;

a second motor, configured to move the objects along a second product pathway relative to the second RFID antenna from a third position in the second scanning zone to a fourth position in the second scanning zone;

wherein the first product pathway is a linear track driven by the first motor; and

wherein the second product pathway is a carousel track driven by the second motor.

9. The kiosk of claim 8, wherein the first motor is configured to move the objects at a known speed.

10. The kiosk of claim 8, further comprising a separator bar disposed in the first product pathway, configured to prevent a given object from completing a circular path around the carousel track.

11. The kiosk of claim 8, wherein the first product pathway includes a chocked track, wherein the first motor drives chocks within the chocked track.

12. The kiosk of claim 8, wherein the second product pathway is configured to deliver items placed thereon to the first product pathway when driven by the second motor.

13. The kiosk of claim 8, wherein the second product pathway is configured to receive items from the first product pathway when the first product pathway is driven by the first motor.

14. The kiosk of claim 8, wherein the first motor is activated in response to the first RFID antenna detecting the objects in the first scanning zone.

15. A method, comprising:

transmitting, via a single RFID antenna in a self-checkout kiosk, a first energization signal;

receiving, by the single RFID antenna at a first time, a first set of identifier signals in response to the first energization signal;

transmitting, via the single RFID antenna, a second energization signal;

receiving, by the single RFID antenna at a second time, a second set of identifier signals in response to the second energization signal;

identifying objects associated with at least one of the first set of identifier signals and the second set of identifier signals and that moved relative to the single RFID antenna between the first time and the second time;

responsive to determining at least some of the objects are detected in both the first and second set of identifier signals, determining whether the at least some of the objects have been added to a transaction at the self-checkout kiosk; and

responsive to determining that the at least some of the objects have not been added, adding the at least some of the objects to the transaction.

16. The method of claim 15, further comprising:

in response to identifying at the first time that that the objects are present at a first position in a scanning zone of the single RFID antenna, activating a motor to move the objects from the first position to a second position within the scanning zone at the second time.

17. The method of claim 15, further comprising:

ignoring identifier signals associated with items outside of a scanning zone of the single RFID antenna.

18. The method of claim 15, further comprising:

using a plurality of distance measurements, at the single RFID antenna, to identify stationary objects in the self-checkout kiosk that are not part of the transaction.

19. The method of claim 15, wherein the at least some of the objects are added to the transaction only if the at least some of the objects have not already been added.

20. The method of claim 15, further comprising:

responsive to determining that a first object of the objects is detected in the first set of identifier signals but not in the second set of identifier signals, add the first object to the transaction only if the first object has not already been added; and

responsive to determining that a second object of the objects is detected in the second set of identifier signals but not in the first set of identifier signals, add the second object to the transaction only if the second object has not already been added.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 11,495,097 B2
APPLICATION NO. : 16/854597
DATED : November 8, 2022
INVENTOR(S) : David Steiner et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

In Column 7, Line 63, delete “FIG.” and insert -- FIGS. --.

In Column 10, Line 41, delete “like” and insert -- like. --.

In the Claims

In Column 16, Line 8, in Claim 16, delete “that that” and insert -- that --.

Signed and Sealed this
Twenty-seventh Day of June, 2023

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office